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Notes on the Biology of the Common Prawn

Palaemon serratus (Pennant)

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Notes on the Biology of the Common Prawn *Palaemon serratus* (Pennant)

INTRODUCTION

At the Fisheries Experiment Station, Conway, a study has been made of the relative performance of various types of prawn pots. At first this work was done in the field, mainly near Holyhead, but later it was transferred to the Conway laboratory, where a captive population of prawns of commercial size was held in a concrete tank of about 20,000 gallons capacity. During the course of this work large numbers of prawns were caught in the Menai Straits and around the coasts of Anglesey and provided material for an examination of certain aspects of growth and breeding.

The literature on the biology of *Palaemon serratus* (= *Leander serratus*) is rather scanty and reveals marked differences of view regarding rate of growth and longevity. Sollaud (1916) considered that prawns lived for 5 or 6 years and that the females did not mature until the end of their second summer or the spring of their third year. Forster (1951) however, concluded that in the Plymouth area most prawns died in their third summer, the females having matured before they were one year old. Such discrepancies seemed to call for a re-examination of these aspects of growth and breeding, more especially as Desbrosses (1951), in a semi-popular article, implied that observations made on the French Atlantic coast had, in general, confirmed the correctness of Forster's views.

DISTRIBUTION

Palaemon serratus is fished commercially along the south coast of England as far as Cornwall and to a small extent in Milford Haven and around the Welsh coast as far as the Menai Straits. It is occasionally found in quantity in the Rivers Crouch and Blackwater in Essex (M. N. Mistakidis, personal communication) and it has been recorded from Norfolk (Gurney, 1923).

An enquiry of Dr. H. O. Bull regarding its status in the Cullercoats area brought the following reply:

'*Leander serratus* is known from the coasts of Northumberland and Durham, by only two specimens in a century. One of them was caught in 1856 by the great Dr. Johnston of Berwick, at Berwick, and given by him to the British Museum; the other was caught by me in Cullercoats Bay on 15th July, 1939, and is here'.

Around the coasts of the Republic of Ireland *Leander serratus* is abundant, particularly in the south-west where a commercial fishery is developing, but it is also found in Northern Ireland (K. Vickers, personal communication), sometimes in fair numbers.

In the Clyde its status has been summarised for me by Dr. R. B. Pike who writes (6.1.56) as follows:

'As far as I can see, *Leander serratus* entered the Clyde sea area within the last 25 years and is still not plentiful although it appears to be increasing in numbers slowly.

It does not occur in the 1901 Fauna and Flora of the Clyde Area edited by G. F. Scott Elliott. . . . It is not in the supplementary list, 1911, Clyde Marine Fauna. . . .

The first record I have . . . within the Clyde area is found in some notes left by A. Milne of his work done on the sub-littoral fauna of Kames Bay, 1938. I later obtained

three specimens in 1946–47. . . . Since then specimens have been taken at irregular intervals in ones and twos, the largest number ever taken in a single haul being 4 in 1952. In the last two years since I have been looking at the decapod larvae, I have found their larvae in the water during August–September in appreciable numbers.'

This is interesting too as recording very late breeding in the Clyde, not unexpected in view of the considerations given below.

METHODS

THE area from which samples were collected is shown in Fig. 1. Collections were made by hand-net from the shore at low water, by trawling where the bottom was sufficiently free from obstructions and by potting. Collections have been grouped according to locality, those from Benllech to Holyhead inclusive being considered as one population and those from the Menai Straits as another (Fig. 1). In fact, little difference was observed between prawns from these two habitats.

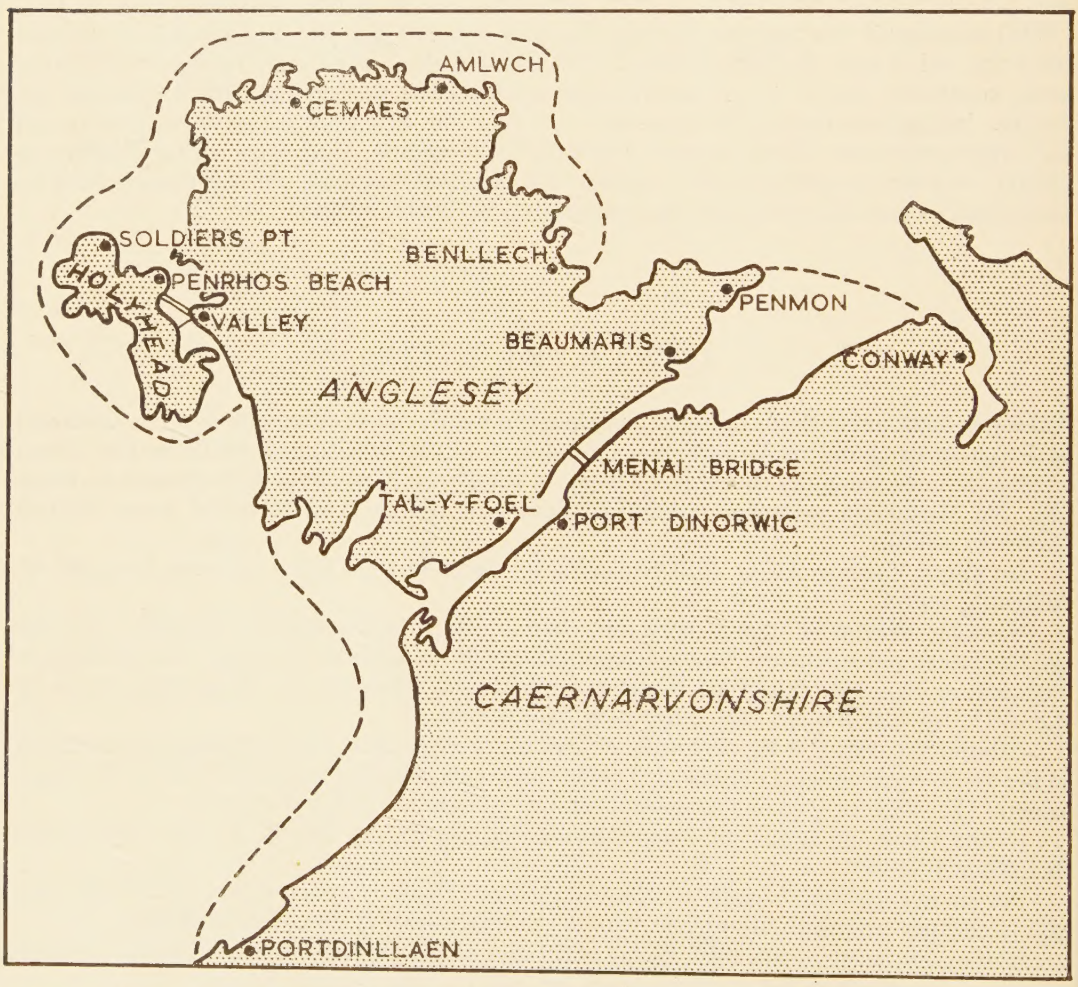


Fig. 1. *Showing the two areas off the North Wales coast from which prawns were collected, referred to in the text as 'Holyhead' and 'Menai Straits'. Each collecting station is named.*

The carapace length, from the base of the eye-notch to the mid-dorsal hinder border, has been measured in all prawns, using a special micrometer (Cole and Mistakidis, 1953). Measurement of the total length introduces subjective errors. The sexes can be distinguished down to a carapace length of about 5 mm; below that size there is little difference between males and females and they were generally classed together as undifferentiated juveniles. Prawns down to 7·5 mm carapace length could be sexed on the basis of the presence or absence of a protuberance between the last pair of walking legs. This protuberance, which occurs in the males only, was mentioned by Havinga (1929) but was apparently overlooked by Forster. The appearance of this part of the ventral surface of the body in the two sexes is shown in Figs. 2A and B. Prawns between 5·0 mm and 7·5 mm carapace length were

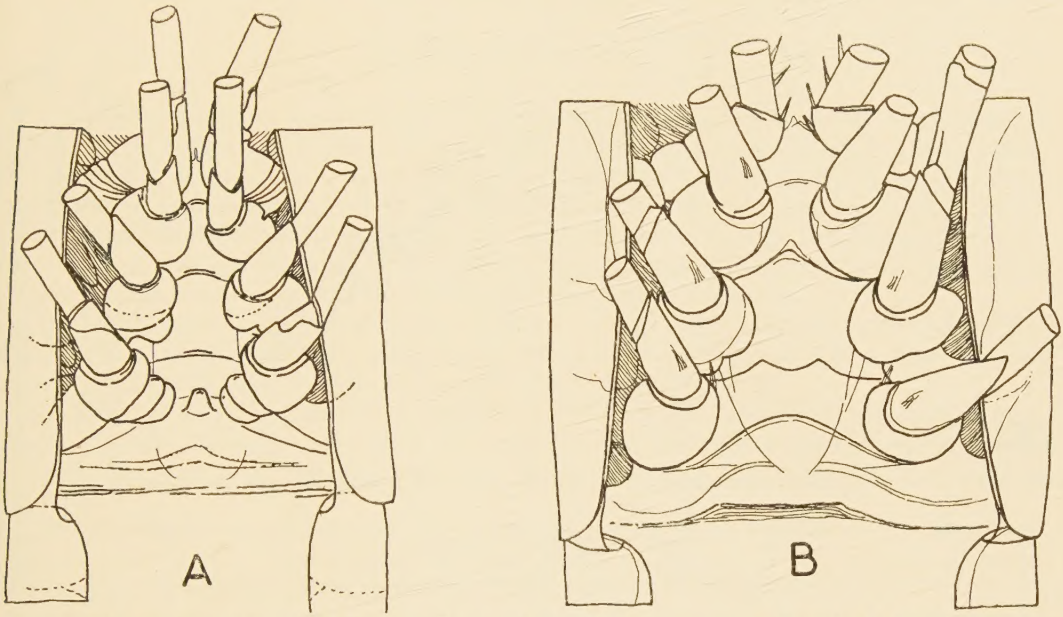


Fig. 2. *The ventral side of the thorax of a typical male* (A), *carapace length* 11·25 *mm, and a typical female* (B), *carapace length* 13·75 *mm.*

sexed by examination (if necessary under a binocular microscope) of the first and second abdominal appendages (Forster, 1951). The total of prawns measured was about 12,000.

All the prawns collected in any one month from each of the areas considered were grouped together for the purpose of preparing the diagrams illustrating growth-rate. Although measurements were made to 0·2 mm, observations were grouped in threes and plotted against the median measurement, e.g., all prawns of each sex measuring 3·8, 4·0 or 4·2 mm were grouped together at 4·0 mm; those measuring 4·4, 4·6 and 4·8 mm at 4·6 mm and so on.

Prawns carrying eggs were noted and the stage of development of the embryos recorded as 'early', 'mid', 'late', or 'hatching'. Females carrying traces of cement on the abdominal pleopods were also recorded.

OBSERVATIONS

THE RELATION BETWEEN TOTAL LENGTH AND CARAPACE LENGTH

THE relation between total length and carapace length in samples of prawns measured without regard to sex is shown in Figs. 3A and B. When males and females are examined

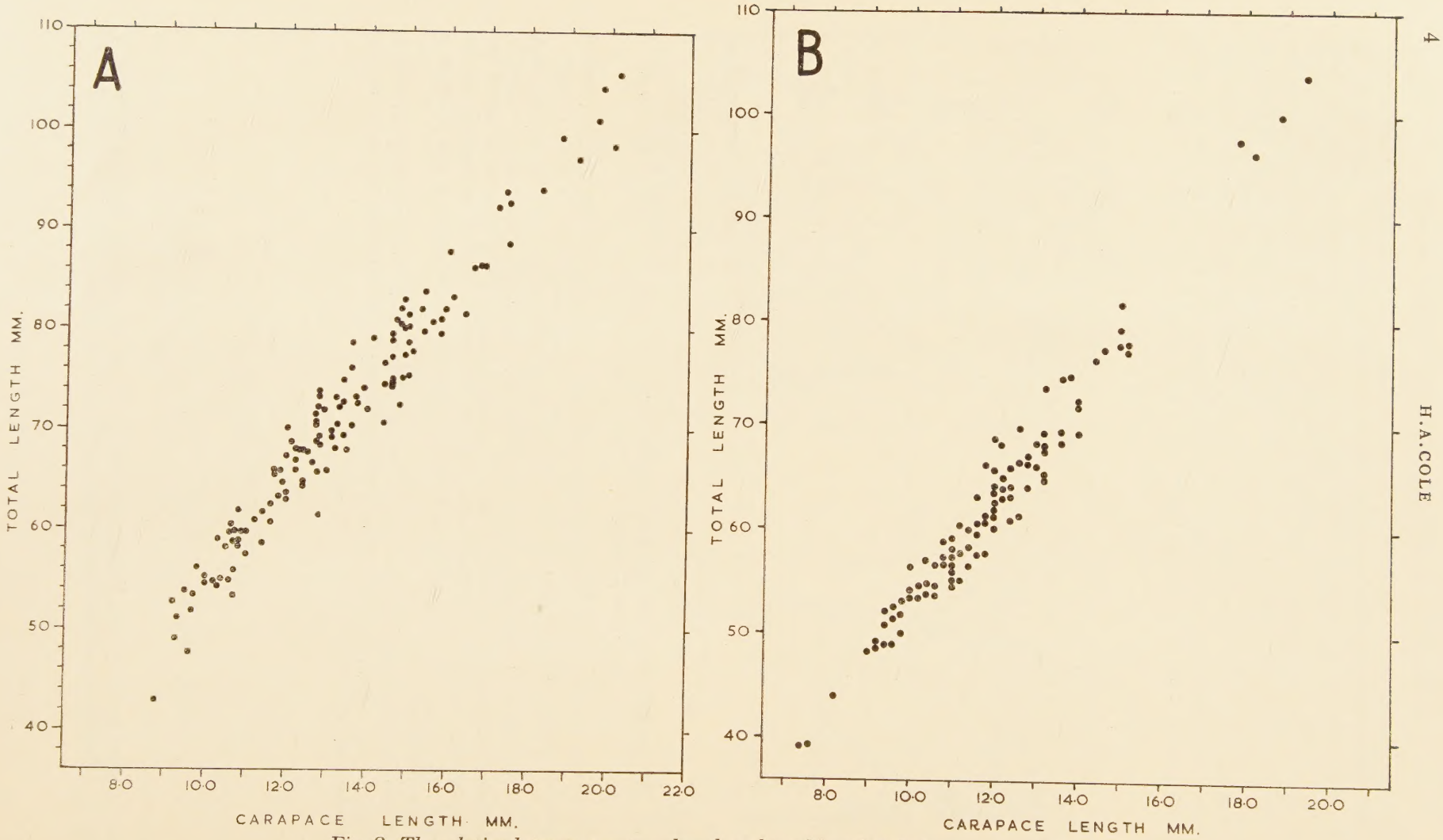


Fig. 3. *The relation between carapace length and total length in* Palaemon serratus.
Sample A was collected from Holyhead (21–22 *September*, 1956) *and sample B from the Menai Straits* (4–29 *July*, 1957).

separately certain differences are revealed. The average values of the ratio $\frac{\text{total length}}{\text{carapace length}}$ in samples of 405 males and 521 females were 5·46 and 5·22 respectively. While the ratio in females appears to be fairly constant throughout life, that in males seems to rise from the second to the fourth growing season and may then decline. In the few very large females examined the ratio had also fallen to about 5·1.

BREEDING

MENAI STRAITS

1952

Of 2 females caught in January, one (17·2 mm) was berried. No catches were made in February. Sampling continued in March, when, however, very small catches were made; 2 of 7 females caught were in berry (18·2 mm, early; 17·2 mm, stage not noted). In April catches were still small but 53·8% of the females 11·0 mm or over in carapace length carried eggs. Berried females ranged in size from 15·2 to 21·4 mm. The stage of development of eggs was not recorded in all examples; all of those examined, except one, were in the early stage, the exception being in the mid-stage of development.

In May a small sample was again collected and, out of 38 females of breeding size, 25 (65·8%) carried eggs. They ranged in size from 16·2 to 24·2 mm, and in none of those examined in detail were the eggs in the early stage of development.

In June, 21 female prawns were caught, all over 15·0 mm, and 20 of these carried eggs. There was only one in an early stage of development and this was a large prawn (20·8 mm) probably carrying a second batch of eggs. Berried females ranged in size from 15·4 to 21·6 mm.

In July slightly larger samples were obtained including 90 females 11·0 mm or over. Only 37 of 90 (41·1%) were berried, but 'cemented' females were comparatively common. Those carrying eggs ranged in size from 14·4 to 22·4 mm in carapace length.

In August only eight female prawns were collected during the first week of the month and two were berried—one 16·4 and the other 20·6 mm (early stage). The latter was presumably breeding for the second time.

No prawns were taken in September and the few collected in October included no berried females.

1953

No collections were made in January or February. On March 25 the first three berried females were obtained from Penmaen Swatch; these were large prawns of carapace lengths, 19·2, 20·2 and 22·0 mm respectively. All the eggs were in an early stage of development. One other berried female, in an early stage of development, was obtained off Puffin Island on March 23; this measured 20·8 mm. Of 19 prawns, 11·0 mm or above in carapace length, only 4 (21·1%) were berried. Spawning was therefore just beginning.

In April, catches of medium and large prawns were still very small; of 13 such prawns, 2 were berried (17·8 and 20·6 mm respectively), both in an early stage of development.

Thus during the late spring only the larger prawns had begun to lay eggs and, even among these, spawning was not general.

May collections from the Menai Straits area were negligible. In June, however, substantial samples of female prawns were obtained covering the size range 7·0 to 23·8 mm. Of 202 berried females, 52, 45 and 105 were recorded as carrying eggs in late, mid and early stages of development. The distribution of these stages of development in relation to size of prawns is shown in Fig. 4. This shows clearly that the larger prawns spawn first and that very few females below 15·0 mm in carapace length spawn before June. The smallest berried female recorded in this month measured 14·0 mm. One prawn was recorded as hatching.

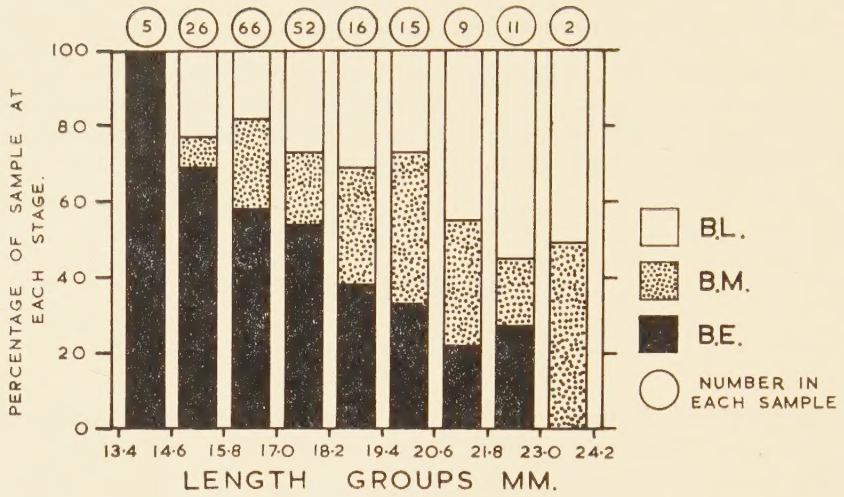


Fig. 4. *Stages of development of the eggs of berried female prawns, collected from the Menai Straits during June,* 1953, *related to carapace length. The total numbers in each* 1·2 *mm size-group are shown in circles along the top of the diagram.*

In July collections were again small; of 28 female prawns 11·0 mm or over in carapace length, 8 were carrying eggs.

In August a better sample was obtained. Of 112 females, 11·0 mm or over, only 4 were berried.

In September no berried females were obtained.

HOLYHEAD

1952

No collections.

1953

No samples were collected during March. In April, 31 female prawns 11·0 mm or over in carapace length yielded no berried females; the majority were taken on April 1. In May, larger numbers were taken—105 11·0 mm or over, including 41 (39·0%) berried. There was also one berried female of carapace length 10·4 mm, the smallest spawning female observed. Of the 42 berried females, all but 3 were recorded as carrying eggs in an early stage of development. As the samples were collected between May 15 and May 21, and included prawns up to 22·2 mm in carapace length, it may be concluded that, in 1953, negligible spawning occurred in April.

In June a large sample of female prawns was obtained but over 50% were below 11·0 mm. Of 297 females 11·0 mm or over, no less than 200 were berried. Early in the month most females carried eggs in an early stage of development, but towards the middle and end of the month, several late stages were recorded (Table 1). Occasional cemented prawns were found. The smallest females carrying eggs measured 12·4 mm and the largest 22·4 mm (corresponding to a total length of about 115 mm).

July collections were again large, containing 454 female prawns including 236 berried (52·0% as compared with 67·3% in June); moreover the majority of the eggs were in an advanced state of development (Table 1) and cemented females were fairly common. The smallest berried female measured 12·0 mm and the largest 24·1 mm (equivalent total length about 123 mm).

Large samples were also taken in August; of 441 female prawns 11·0 mm or over in carapace length, 46 were berried (10·4%). Those berried included both unusually small and

Table 1: *Weekly catches of berried female prawns from Holyhead, Season* 1953

Date	STAGE OF DEVELOPMENT OF EGGS *Early*	*Mid*	*Late*	*Total Berried Females*
13 – 19 May	16	0	0	16
20 – 26 May	23	3	0	26
27 May – 2 June	2	0	0	2
3 – 9 June	42	2	3	47
10 – 16 June	92	4	7	103
17 – 23 June	30	1	0	31
24 – 30 June	10	4	4	18
1 – 7 July	52	16	4	72
8 – 14 July	No records			
15 – 21 July	0	3	12	15
22 – 28 July	3	18	48	69
29 July – 4 August	2	17	82	101
5 – 11 August	1	1	18	20
12 – 18 August	No records			
19 – 25 August	No records			
26 August – 1 September	0	0	3	3
2 – 8 September	0	0	1	2
				525

unusually large females. On August 7, 2 females 11·2 mm carapace were taken with early and mid-stage eggs respectively; towards the close of the month (Table 2) three very large berried females were taken, all with eggs in a late stage of development. These were presumably spawning for a second time.

In September similar very large berried females were found among three collected early in the month; the eggs of these were also in a late stage of development. No samples were taken during the remainder of the month.

The October collections, comprising 250 females, contained none carrying eggs.

1954

Good samples of female prawns were obtained in July, but many were below 11·0 mm and all were below 16·8 mm in carapace length. Of 379 females 11·0 mm or over, only 3 carried eggs. These measured 13·8, 14·0 and 14·4 mm respectively.

In August only 45 females 11·0 mm or over were taken and none were berried.

THE PERIOD OF EGG-CARRIAGE

The approximate length of the period of egg-carriage can be deduced from Table 2. Since females carrying eggs do not moult, then if we select a category of moderately large prawns, e.g., 17·0 to 19·8 mm, the laying, development and hatching of the eggs should be shown

Table 2: *Size-distribution of female prawns from Holyhead, Season* 1953

B — Berried *N.B.* — Not berried

	Carapace length — mm									
	11·0 – 13·8		14·0 – 16·8		17·0 – 19·8		20·0 – 22·8		23·0 – 25·8	
	B.	*N.B.*	*B.*	*N.B.*	*B.*	*N.B.*	*B.*	*N.B.*	*B.*	*N.B.*
1 – 14 April	–	11	–	16	–	1	–	–	–	–
15 – 28 April	–	1	–	1	–	1	–	–	–	–
29 April – 12 May	No records									
13 – 26 May	3	31	29	32	8	1	2	–	–	–
27 May – 9 June	15	18	24	13	9	1	1	–	–	–
10 – 23 June	27	36	90	23	11	–	6	–	–	–
24 June – 7 July	18	8	61	15	8	1	2	–	1	–
8 – 21 July	1	–	12	4	2	–	–	–	–	–
22 July – 4 August	37	79	126	126	5	23	2	4	–	–
5 – 18 August	2	119	18	171	–	14	–	–	–	1
19 August – 1 September	–	12	–	10	–	13	3	19	–	2
2 – 15 September	–	1	–	–	–	5	2	16	–	1

in the table. In April none were berried; towards the end of May the first berried female appeared; throughout June all female prawns of this size carried eggs, but from July 3 onwards there was a rapid decline in the percentage carrying eggs. In the first week in August, 14 female prawns taken of this size included none with eggs. The approximate period of egg-carriage therefore was from mid-May to the end of July, i.e., about $2\frac{1}{2}$ months.

In the category 14·0 to 16·8 mm carapace length, it is likely that there was a steady addition of females of spawning length during the summer and thus the picture is obscured, but it will be noted that berried females were first observed on May 15 (the May collections were small), while during June a very high percentage of berried females occurred. This situation continued until the last week in July when a rapid decline in the percentage of berried females was observed. During the first week of August some additional berried females in this size group were taken, but after August 7 no more were collected. Thus the average period of egg-carriage was at most 3 months.

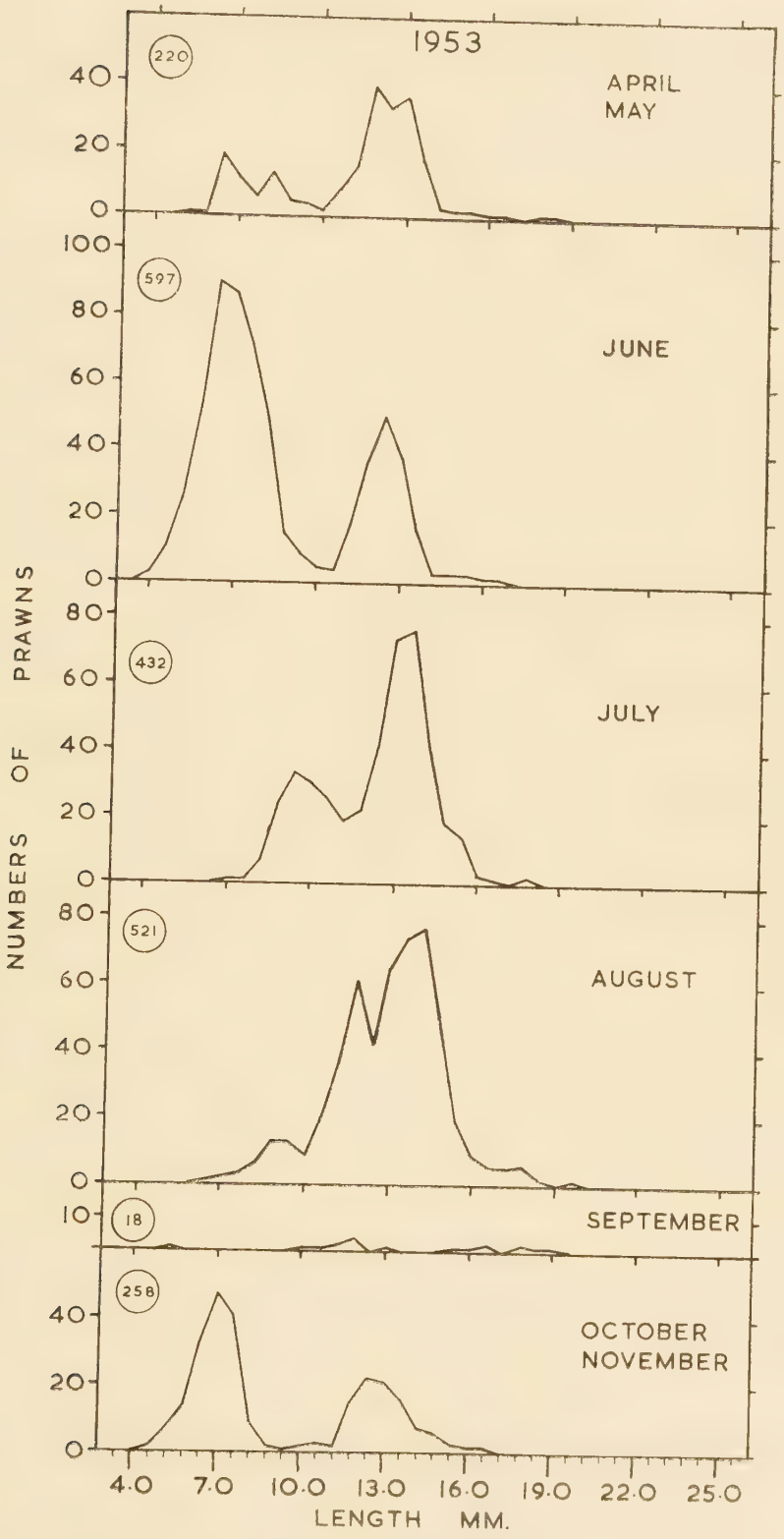
The same conclusion is reached from an examination of Table 1, where the stage of development of the eggs on each berried female is recorded. Until the end of the third week of June early stages predominate; after mid-August they are scarce. This suggests an incubatory period not greatly exceeding 2 months.

GROWTH

MALES

Holyhead

The largest samples were taken in 1953 from near Holyhead, and it will be convenient to interpret them first.



ig. 5. *The size-distribution of male prawns from the Holyhead area collected during* 1953. *n this and subsequent figures the total numbers in the samples are shown enclosed by circles.*

1953

The size-distribution of the large June collection (Fig. 5) shows very clearly defined peaks at 6·4 to 7·0 mm and 12·4 mm and these clearly represent the groups approaching one and two years old respectively. The growth of these year groups can be followed easily through July and August to October (Fig. 5), in respect of the 1 year old prawns, and to August in the 2 year group. The mode of the 1 year group in October lies at 12·4 to 13·0 mm, the expected position, having regard to the size of the previous year group in June.

The two year old prawns grow slowly and in August are being rapidly overhauled by those a year younger. After August the two year old prawns were not represented in the samples except by a very few individuals, and it is to be assumed that they had migrated offshore.

The new season's 0-group is well shown in the October samples with a mode at 7·0 mm, a position very close to that of the previous year's group when caught in early June, before active growth had begun.

These samples contained some of the largest male prawns collected, having a carapace length of 19·6 mm. This is equivalent to a total length of about 100 mm.

1952

The smaller samples collected in 1952 (Fig. 6) may now be interpreted. The 0-group shows a peak at the expected length (7·0 mm) and there are also clear indications of the one year old prawns at a carapace length of 13·0 mm and of the two year old prawns, missing in the 1953 collections, at 15·4 mm. Reference to Fig. 5 will show that this 2 year group showed a peak at 13·6 to 14·2 mm in August 1953, when it was very strongly represented in the catches.

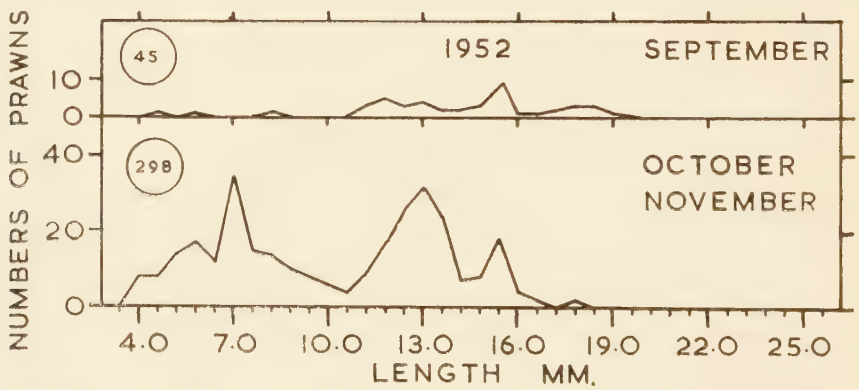


Fig. 6. *The size-distribution of male prawns from the Holyhead area collected during* 1952.

1954

Only two samples were collected, in July and August (Fig. 7), and they consisted almost exclusively of 1 year old prawns. The size-distribution curves are peaked at 10·0 mm in July and 10·6 mm in August. The corresponding figures in 1953 were 9·4 to 10·0 and 11·8 mm.

1956

The one sample of male prawns taken in 1956 from this area confirms the existence, in normal years, of a strong group of yearling prawns at carapace length *ca.* 11·8 mm (Fig. 8).

Menai Straits

1953

The 0-groups of 1952 and 1953 are both clearly defined in the size-distribution curves

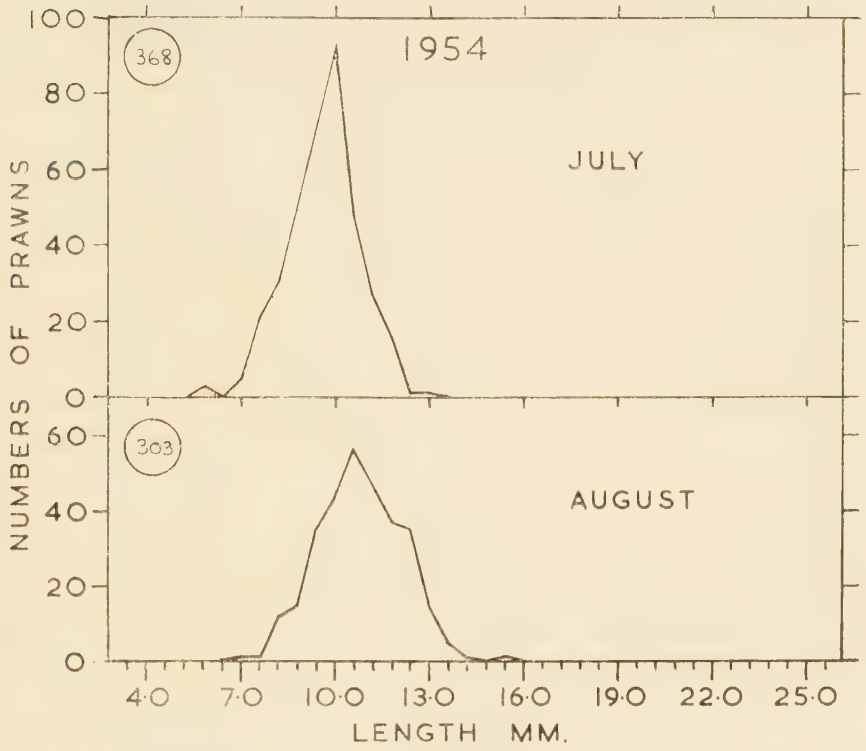


Fig. 7. *The size-distribution of male prawns from the Holyhead area collected during* 1954.

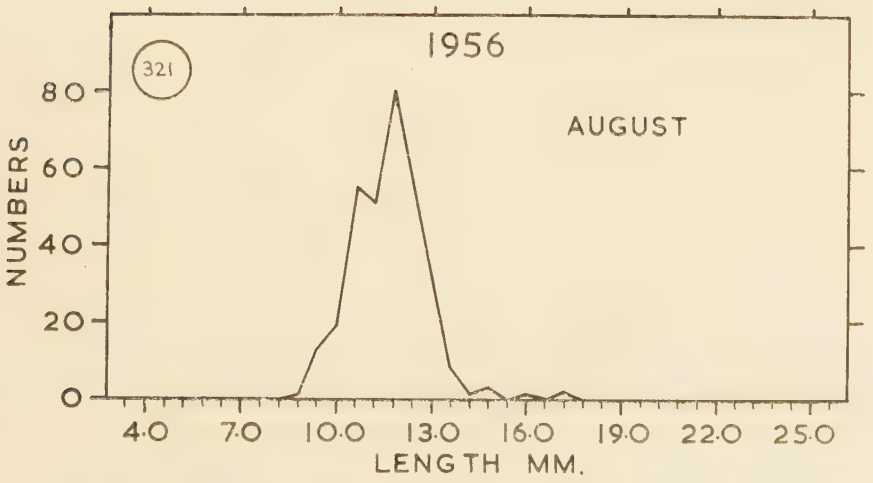


Fig. 8. *The size-distribution of male prawns from the Holyhead area collected during* 1956.

(Fig. 9) with peaks at 6·4 mm in the spring (1952 hatch) and 7·0 mm in the autumn (1953 hatch). The growth of the 1952 0-group can be seen through June to August, the greatest number being then 11·8 mm. These prawns were therefore slightly smaller than those of similar age from Holyhead. A group of prawns completing their second year, with a peak at 13·0 to 14·2 mm in June, can also be discerned, but their subsequent growth cannot be followed.

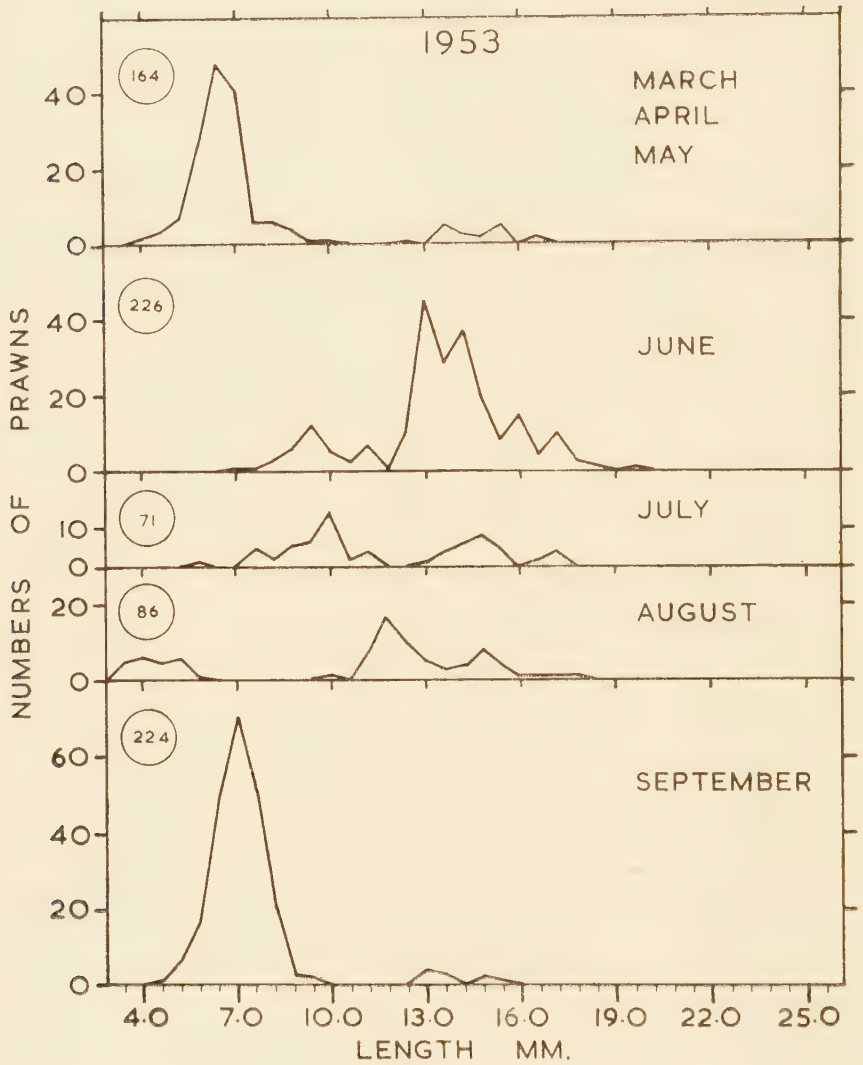


Fig. 9. *The size-distribution of male prawns from the Menai Straits collected during* 1953.

1952

These samples are not large (Fig. 10), but in three of them there is a group, at 14·2 mm mode in May, 14·8 mm in June and *ca.* 15·4 mm in July, which can be recognized as that of 1949, attaining 3 years in July.

1956

A sample of sixty-six prawns collected in September (Fig. 11) showed a mode at 13·0 mm.

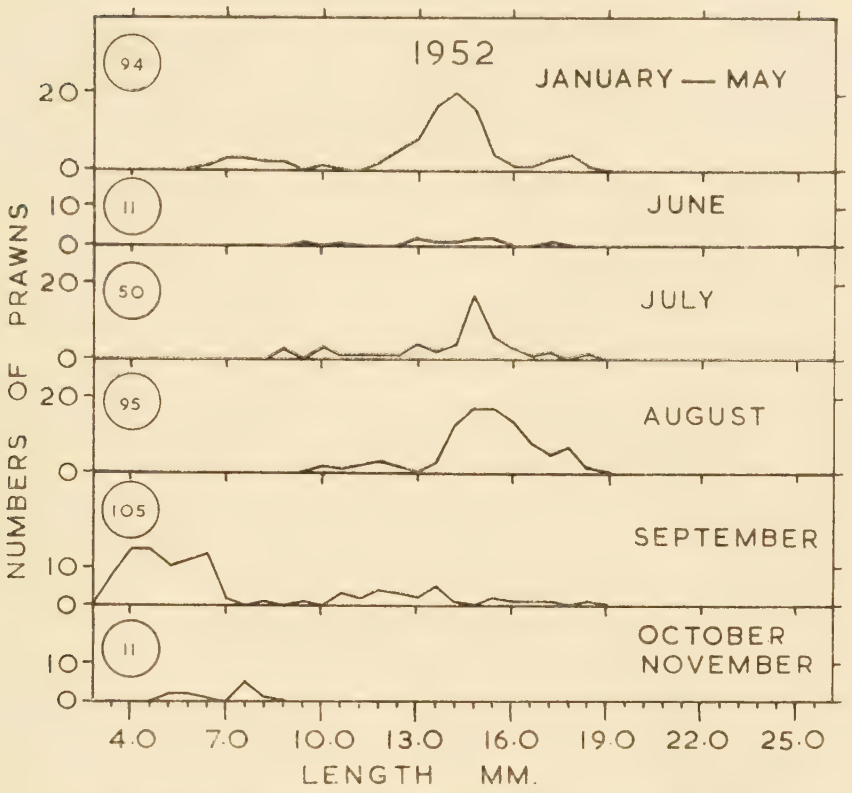


Fig. 10. *The size-distribution of male prawns collected from the Menai Straits during* 1952.

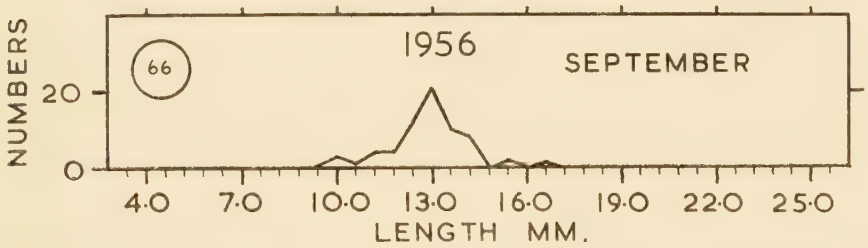


Fig. 11. *The size-distribution of male prawns collected from the Menai Straits during* 1956.

FEMALES

Holyhead

1953

The May and June catches (Fig. 12) show a clearly defined 0-group, peaked at about ·0 mm, so that up to 1 year old there is no difference in the rates of growth of males and emales. The 0-group is again evident in the October catches. The 1 year old prawns are listinct in the May and June catches with modes around 13·6 to 14·2 mm. This year roup is distinct in July also (mode 14·8 mm) with the yearling prawns at about 11·2 to 1·8 mm carapace length.

In August the one and two year groups overlap to a very large extent, the 1-group aving grown substantially while the older female prawns (all carrying eggs in July) have ardly grown at all. The size-distribution curve embracing these two groups is widely pread at its base, with the two peaks merged; a similar situation is evident in the October ample.

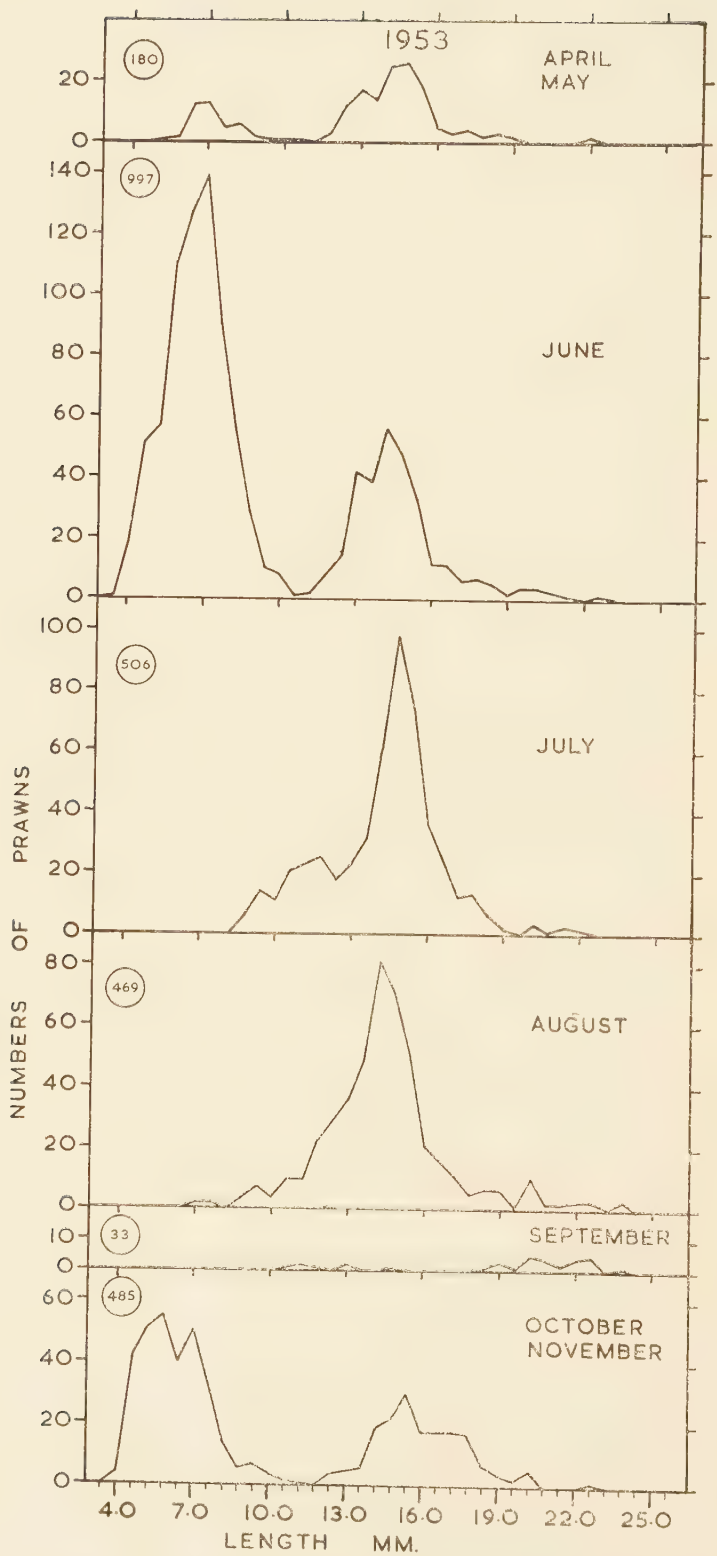


Fig. 12. *The size-distribution of female prawns collected from the Holyhead area during* 1953.

1952

The only catches of female prawns were in September and October and later. The 0-group shows up (Fig. 13) in the expected position in October but the older groups are merged. There is clear evidence from this figure of the existence of at least 5 year groups at that time of the year.

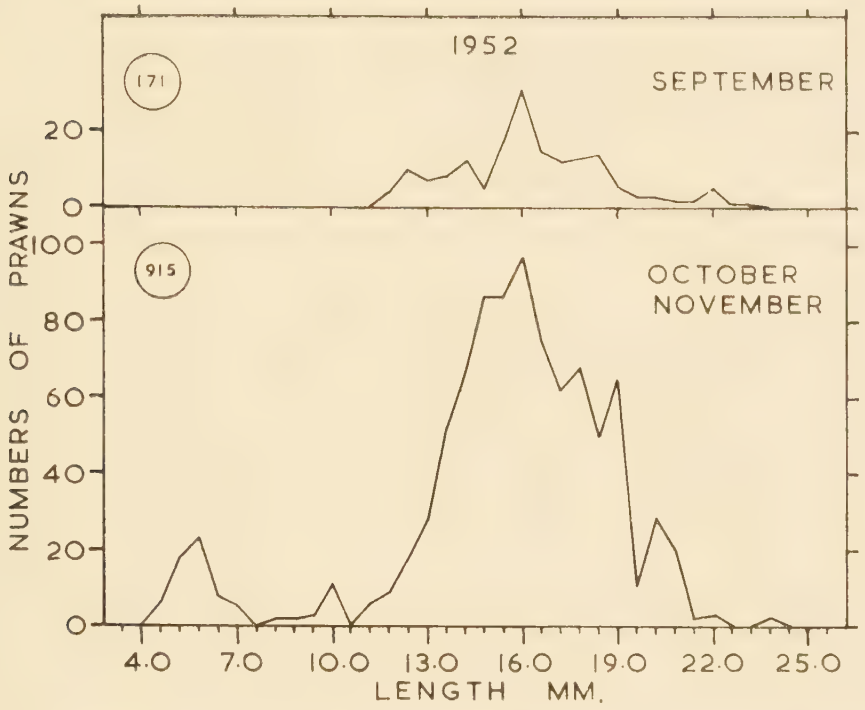


Fig. 13. *The size-distribution of female prawns collected from the Holyhead area during* 1952.

1954

Samples were collected in July and August only (Fig. 14) and consist almost entirely of yearling prawns. There is a mode at 10·6 mm in July and 11·8 in August. It will be recalled that the comparable figures for males were 10·0 and 10·6 mm. Thus there is at this period a difference in the rate of growth of the two sexes. The larger of these yearling females will have a period of egg-carriage in July with a consequent stoppage of growth.

1956

Only one sample was collected in August, but this shows a very strong group of yearling prawns—mode at 12·4 mm (Fig. 15).

Menai Straits

1953

The 0-groups of 1952 and 1953 are strongly represented in May and September (Fig. 16), with peaks at 5·2 to 5·8 mm and 7·0 mm respectively. Otherwise the samples are relatively uninformative, although there is a strong group around 16·6 mm in June (presumably rising 3 years old), and a surprising number of very large female prawns, including a few at 23·8 mm carapace length, representing a total length of approximately 123 mm. These could not be less than 5 years old.

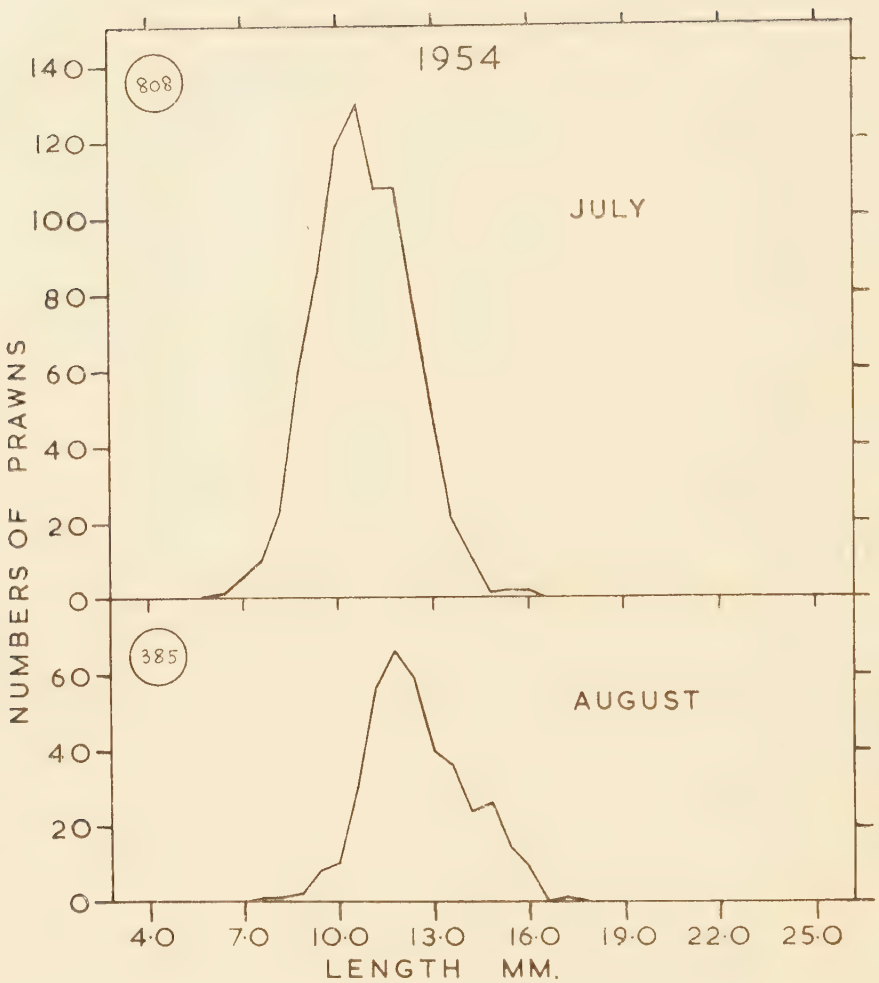


Fig. 14. *The size-distribution of female prawns collected from the Holyhead area during* 1954.

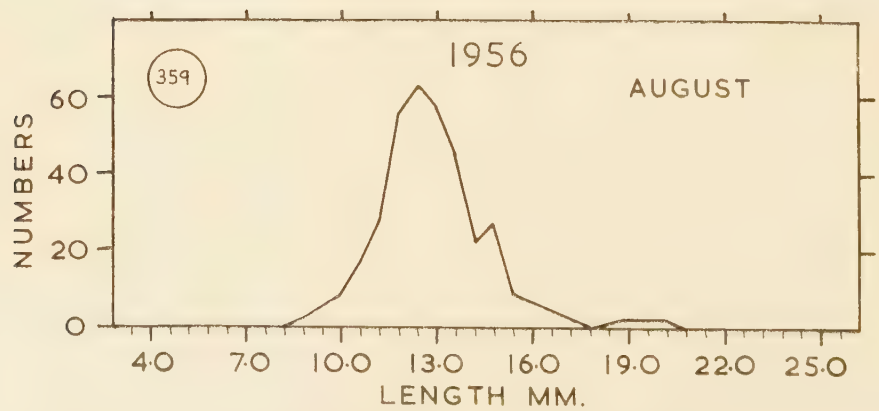
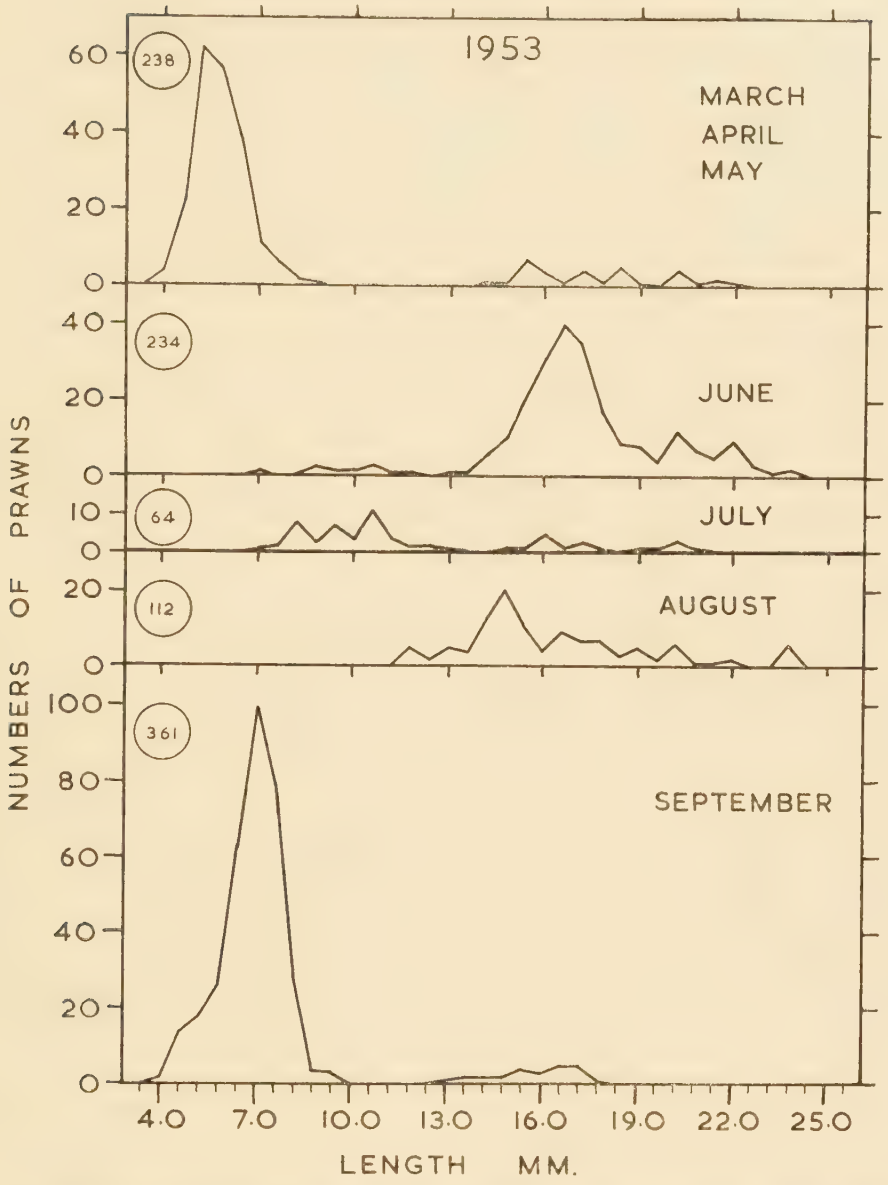


Fig. 15. *The size-distribution of female prawns collected from the Holyhead area during* 1956.



ig. 16. *The size-distribution of female prawns collected from the Menai Straits during* 1953.

952

The interpretation of these curves (Fig. 17) is fraught with difficulty but there are rong suggestions of at least 2 peaks between 16·0 and 22·0 mm. These are of interest in onfirming the belief that, in North Wales waters, female prawns survive for at least 5 years. hose prawns around 17·0 mm carapace length early in the year cannot be less than 3 years d; growth at that age has slowed down considerably, so that the prawns of 21·0 mm are kely to be five years old. The few prawns of 23·0 mm or more may be a good deal older.

955

In order to settle finally the rate of growth of the 0-group, a large sample was collected om the Menai Straits in early September. The size-distributions of males and females

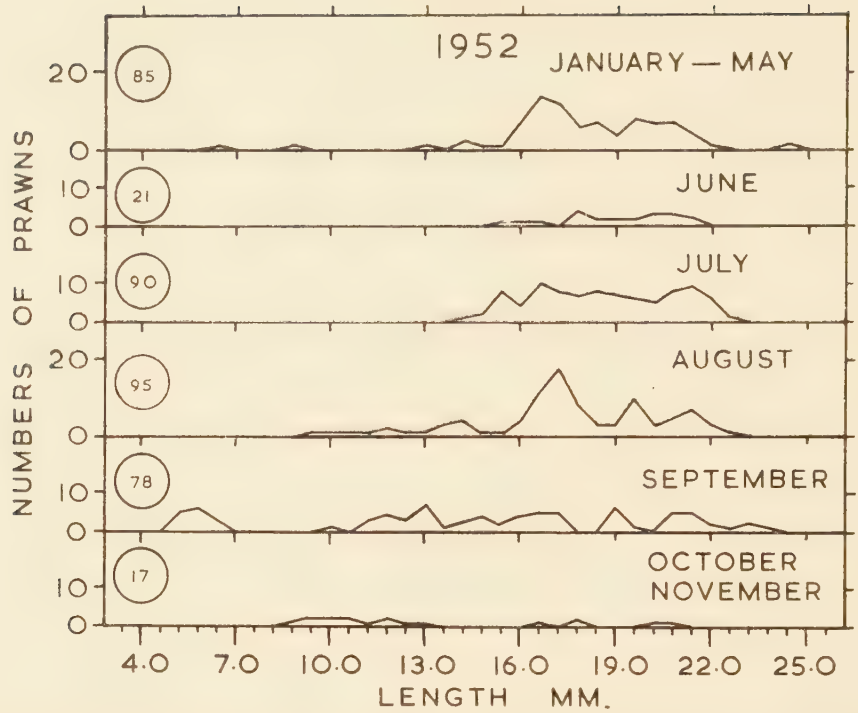


Fig. 17. *The size-distribution of female prawns collected from the Menai Straits during* 1952.

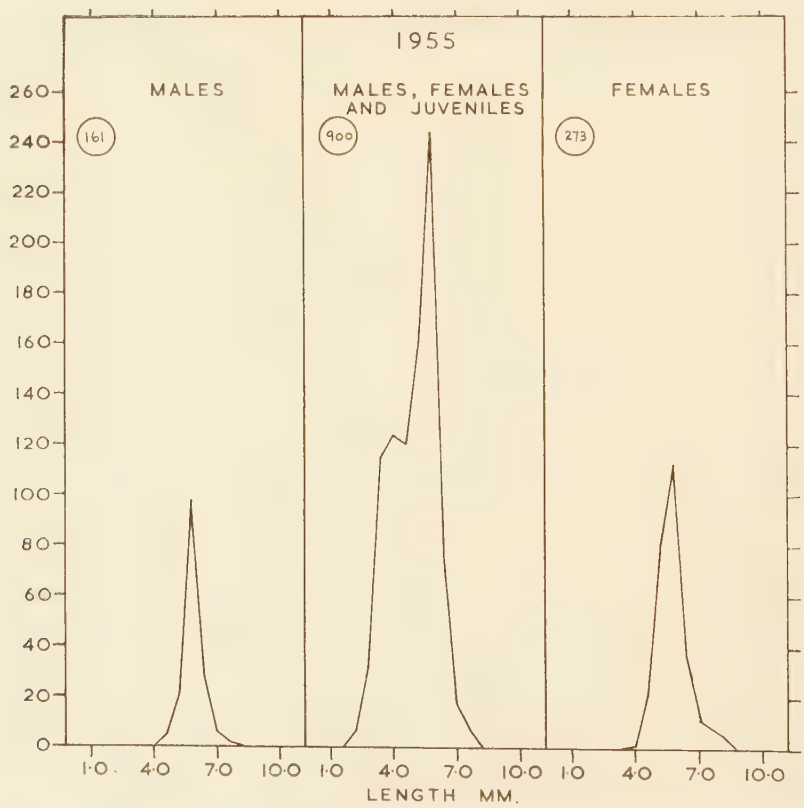


Fig. 18. *The size-distribution of prawns hatched in* 1955 *collected from rock pools in the Menai Straits during September,* 1955. *The aggregated sample is shown in the middle section of the figure. Only prawns above a carapace length of* 4·0 *mm can be readily sexed.*

Fig. 18) both showed clearly marked peaks at 5·8 mm. There were very numerous undifferentiated juveniles down to 2·2 mm in carapace length. These young prawns would continue to grow during September but it is clear that they would not greatly increase their size, and they could not be expected to average more than 7·0 mm, which was the position of the mode in large samples collected in late 1953 in the same area.

1956

The small sample collected in September (Fig. 19) is of interest only because of the presence, once again, of large prawns 3 to 5 years old.

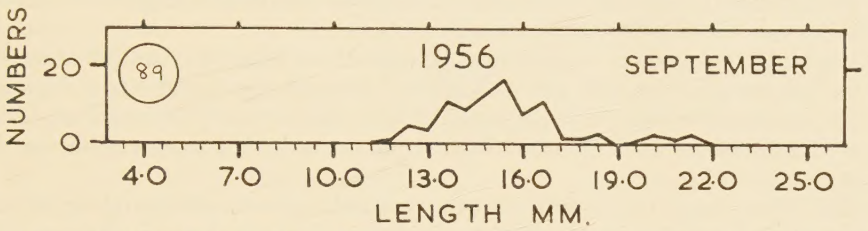


Fig. 19. *The size-distribution of female prawns collected from the Menai Straits during* 1956.

PARASITES

Although about 12,000 prawns of all ages were examined during the present study, no infection of *Palaemon serratus* by *Bopyrus fougerouxi* Giard and Bonnier was found. Of several hundred *Palaemon elegans* Rathke (= *Leander squilla* (L)) examined incidentally, only one example carried a parasite.

This absence of the parasite is remarkable, as in some River Crouch samples taken by Mr. M. N. Mistakidis, and kindly placed at my disposal, 7 out of 298 were parasitized. At Plymouth the parasite is common (Plymouth Marine Fauna, 1957 and Forster, personal communication), but it is not recorded from the Isle of Man. At Roscoff the parasite is very common (Nouvel Van Rysselberge, 1937).

Nouvel Van Rysselberge investigated the frequency of moulting and growth in prawns affected by *Bopyrus*, but concluded that the parasite had no effect. The same author recorded two prawns infected by *Nectonema agile* Verr., but so far as is known this has not been recorded from Britain.

DISCUSSION

The picture of spawning, development and hatching obtained from the study of North Wales prawns differs substantially from that given by Forster for the Plymouth section of the Channel. Spawning begins in North Wales approximately 3 months later than at Plymouth and the period of egg-carriage is only $2\frac{1}{2}$ to 3 months, compared with 4 months at Plymouth. An explanation is to be sought in the difference in the time of year when incubation takes place. In North Wales this is usually from mid-April to the end of July; at Plymouth the period varies from December to March in the largest breeding prawns, to March to July inclusive in the smallest. It seems likely that water temperatures below about 8°C inhibit spawning and in consequence female prawns in North Wales are unable to lay their eggs until April. Off Plymouth, in normal seasons, winter water temperatures do not fall substantially below 8°C, except for short periods, and egg laying proceeds throughout the coldest part of the winter, i.e., from December to February inclusive. On the other hand the average early summer sea temperatures off the North Wales and Plymouth coasts

are very similar so that, once laid, eggs on the North Wales prawns will develop rapidly, more so than at Plymouth in the early spring months. Consequently the period of incubation is shorter in North Wales, in correlation with the higher average water temperature (*see* Atlas de Température et Salinité, 1933 and Bowden, 1955).

Off Roscoff, Nouvel Van Rysselberge (1937) states that she has observed an incubation period of only 5 weeks in spring, but no supporting details are given.

At Plymouth large prawns normally spawn twice and may possibly spawn a third time, whereas off the North Wales coast double spawning is not common, being apparently confined to a small percentage of the largest females. Off the French coast three spawnings per annum is said to be the normal occurrence (Desbrosses, 1951), leading to the presence of larval stages in the water as late as October.

Hatching begins in inshore waters near Plymouth in May. Cemented females were recorded by Forster (his Fig. 14) only in May and June. Large females carrying eggs in a late stage of development were however taken offshore on February 18 and it was estimated that they would have hatched in March. There is an unconfirmed report of berried females from the same area in November.

Off North Wales, eggs in a condition near to hatching were not found until June and most larvae emerged in July. Cemented females were not noted except in July and August, but this stage lasts only a few days.

Off the Atlantic coast of France hatching begins in April (Desbrosses, 1951). Nouvel Van Rysselberge (1937) states that off Roscoff berried females may be found at all times of the year, except towards the end of summer and at the beginning of autumn. Desbrosses (1951), however, gives the period of occurrence of berried females off the French coast as November to June; the smallest berried female measured 60 mm. As noted by Sollaud and Forster, there is a correlation between size and age of female prawns and earliness of spawning and hatching of eggs (see Fig. 4). Desbrosses (1951) also gives particulars of the numbers of eggs carried by females of various sizes, varying from 1,500 at 60 mm to 4,200 at 105 mm total length.

The pattern of growth, as revealed by the North Wales samples, is also very different from that deduced by Forster. In both males and females the 0-group in North Wales averages 6·4 to 7·0 mm carapace length in October, at the end of the first growing season. The picture is consistent from year to year and the samples are large.

Forster, however, considers that the 0-group in the Plymouth area averages 52·5 mm total length in October, corresponding to a carapace length of about 10·0 mm. One must conclude from his account that very rapid growth occurs in September since his August samples (taken towards the end of the month) contained no prawns larger than 35 mm, while the average size was no more than 25 mm, equivalent to a carapace length of only about 5·0 mm. This would be the expected size in North Wales, but, unfortunately, few of our samples contain 0-group prawns at that time of the year.

The three October samples from Plymouth (Forster, 1951, Fig. 3, p. 337) also seem to be bi-modal. Support for this conclusion is given by a study of the size-distribution curves, including reputed 0-group prawns, given at the bottom of Forster's Figures 4 and 5 (pp. 338–339); neither of these curves has the shape expected for a normal distribution. It is possible that these bi-modal curves might be explained as being due to the long-continued breeding season with broods of larvae emerging at wide intervals, but, in fact, Forster did not find post-larval and young stages until they appeared together in rock pools in July—this is general experience. Although these young stages ranged fairly widely in size in July, the largest was 25 mm in length. It is very difficult to imagine these 25 mm prawns growing to 67·5 mm by October while similar 0-group prawns from North Wales, also appearing in rock pools towards the end of July, do not exceed 45 mm at the end of the year.

If this interpretation of Forster's data is correct, then the average size of the 1-group at the end of the second season's growth would be about 57·5 mm, equivalent to a carapace length of about 11·0 mm, with little or no difference between the sexes. The corresponding figures for N. Wales prawns appear to be about 12·4 mm for males and about 14·2 mm for females. It is likely that Forster's figure was lower than the true figure because of the collection of samples close inshore where 0-group prawns were more often found. Some of

he larger 1-group females may have moved offshore. Forster's selected samples of females his Fig. 4) provide evidence of peaks in the October, January, February, May and July urves at the expected position (67·5 to 72·5 mm), representing females rising two years old. His selected samples of older males (his Fig. 5) show well-marked peaks in October, December and January at 62·5 mm, equivalent to a carapace length of about 12·0 mm. One an conclude, therefore, that there is very little difference between the growth-rate of prawns up to 2 years old in the inshore areas of Plymouth and North Wales.

Forster notes that his conclusions on growth do not agree with those of Nouvel Van Rysselberge (1937). This author gives a scheme of moulting and growth in *Palaemon erratus* which assumes that ten moults, and a growth in length of 25 mm, occur during the winter period October to June. Certainly no growth occurs in Britain during that period and Sollaud (1916) had previously recorded that growth was suppressed in winter in France, subsequently confirmed by Desbrosses (1951). Nouvel Van Rysselberge records finding post-larval prawns of 10 mm total length in rock pools near Roscoff at the beginning of June. From observations of their moulting in the laboratory she considers that they average 26 mm in October, having moulted eleven times.

It seems very significant that the total length reached in the Roscoff laboratory in October should be so similar to that recorded in the present study. 6·4 mm carapace length, the average size reached in North Wales, is equivalent to a total length of about 32 mm. That this figure should be slightly above that recorded in laboratory rearing experiments is not surprising since some depression of growth-rate in captivity is general experience and, indeed, was recorded by Nouvel Van Rysselberge herself.

The figures given by this author for later growth suggest that, in their second year, prawns at Roscoff grow from 26 to 51 mm, in their third year from 51 to 74·5 mm, and in their fourth season from 74·5 to 89·5 mm. A few prawns survive to their fifth summer. These figures seem to be those for female prawns since Nouvel Van Russelberge found only a small number of males exceeding 65 mm. The maximum size observed for this sex was 71 mm (Nouvel, 1934). At Plymouth Forster found males up to 97·5 mm; in the present material from N. Wales the largest male had a carapace length of 19·6 mm equivalent to a total length of about 100 mm.

Nouvel Van Rysselberge found numerous females of about 80 mm but those of 90 mm were less common. The maximum size found (Nouvel, 1934) was 106 mm. Forster records females up to 107·5 mm, while in the present investigation the largest collected was 24·4 mm carapace length, equivalent to a total length of perhaps 120 mm.

Desbrosses (1951) stated that net catches of prawns from the French Atlantic coast contained in May 1950 three groups of females with lengths predominantly of 70, 90 and 110 mm. It was considered that these were 1, 2 and 3 years old respectively, but the results of the present investigation suggest that each group was one year older than estimated.

It seems probable therefore that prawns normally live for 4 full years with a fair proportion reaching 5 years old and a few living even longer.

Nouvel (1934) recorded a predominance of females in her prawn catches; it is interesting to note a similar situation in catches from North Wales. The 1953 catches from Holyhead contained 2,620 females and 2,046 males; those from the Menai Straits included 1,009 females and 771 males.

SUMMARY

1. Growth and breeding of *Palaemon serratus* (Pennant) in North Wales is described from the examination of about 12,000 specimens. No substantial differences were found between populations living in the sheltered waters of the Menai Straits and those from the north coast of Anglesey.

2. Few female prawns of less than 11·0 mm carapace length were found carrying eggs. While a few of the larger females carried eggs in January to April, egg laying was not general

until May. There was a correlation between size and age of female prawns and earliness of spawning and hatching of eggs. The period of egg-carriage was about $2\frac{1}{2}$ months. The only berried females taken in September were very large prawns presumed to be breeding for a second time.

3. In North Wales, samples of both males and females of the 0-group averaged 6·4 to 7·0 mm carapace length in October at the end of the first growing season. Yearling prawns averaged about 12·4 mm carapace length among males and 14·2 mm carapace length among females at the end of the second growing season.

4. Growth patterns in the third and subsequent summers were not so clear but it seems probable that many prawns live for four full years with some reaching or exceeding five years old.

5. The relation between carapace length and total length is shown to differ slightly according to the age and sex of prawns. The mean values of the ratio $\frac{\text{total length}}{\text{carapace length}}$ were 5·46 and 5·22 in males and females respectively.

6. The parasite *Bopyrus fougerouxi* (Giard and Bonnier) has not been found on *Palaemon serratus* (Pennant) in North Wales and only once on *Palaemon elegans* Rathke.

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